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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Grease: Its Manufacture and Usage

Lubrication of the Steering Engine and Deck Auxiliaries

PUBLISHED MONTHLY BY
THE TEXAS COMPANY, U.S.A.
TEXACO PETROLEUM PRODUCTS

"—without prejudice"

THERE ARE some bearings which can only be lubricated with oil.

Some only with grease.

Then there are some which, apparently, may be lubricated with either—but the correct selection of the type of lubricant used may determine the operating efficiency.

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and

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* * * * * * * * *

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THE TEXAS COMPANY, U.S.A.

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Grease: Its Manufacture and Usage

THE remarkable evolution of lubrication from a crude rudimentary procedure to a veritable science over the past 20 years has developed innumerable points of the utmost interest to engineers as to various types of lubricants, their properties and their usage. When and where to use mineral lubricating oils, compounds of mineral and animal or vegetable products and semi-solid lubricants has been the cause of much study, research and discussion. Among these the question of grease lubrication and its relative adaptability to certain types of mechanical equipment is interesting indeed.

Description

Greases, or, as they are sometimes termed, semi-solid lubricants, are essentially intimate emulsions of mineral lubricating oils and soaps from animal or vegetable fats, the emulsifier being water or some other agent. The mineral oil is entrained in the soap, which serves as a thickener, much in the same way that water is held by a sponge. The resultant mass is homogeneous in appearance and action if the mixing has been properly carried out. As understood today semi-solid lubricants are of such density that they will not flow readily at ordinary temperatures. While most semi-solid lubricants are mixtures of mineral oils and saponified animal or vegetable fats, these latter, such as tallow, lard and palm oil, as well as certain pure mineral products of the nature of petrolatum, are also classed in this category. Essentially the generally accepted classification is as follows:

1. Pure mineral grease such as petrolatum, gear lubricants, and other highly viscous products.

2. Pure animal and vegetable fats such as tallow, lard, and other non-fluid products.

3. Mixtures of pure fixed oil fats and pure mineral greases.

4. Mixtures of soaps and mineral oils, such as cup, sponge and railroad greases.

The products included under Nos. 1 and 4 are most commonly used as lubricants where grease lubrication is desirable. Under classification No. 4 we have what are known to the grease maker as hot and cold set greases, i.e., greases that are mixed while hot and those that are cold mixed. Cold mixed products include axle and railroad greases, while the various grades of cup and sponge greases are hot mixed. By varying the constituents such greases may be produced in many grades, each having characteristics intended to fit it for a particular type of service.

In the cold mixed greases the chemical action takes place in the shipping container immediately after mixing and the grease has been poured. In the hot mixed greases chemical ac-

tion occurs in the mixing kettles. In both cases the result of such reactions is the formation of the soap body of the grease. While the lubricating value of the grease depends to a large extent upon the lubricating value of the oil used, on the other hand the grade and amount of soap used will naturally have a certain effect upon the general appearance, body and other physical characteristics of the resultant product.

Properties Grease Should Possess

Whatever the type of service it is designed for, lubricating grease should possess certain very definite properties if it is to give successful and satisfactory results, viz:

1. Its melting point and hardness should be definitely adapted to the operating temperature and pressure where it is to be used.

2. It should have sufficient body to insure a film of lubricant between the bearing surfaces under the maximum possible pressure that might occur.

3. It should contain no so-called non-lubricating fillers such as asbestos, talc, soapstone or chalk, which are used mainly as cheap mediums to give greater viscosity or body. Such substances will contain a certain amount of grit and will cause scoring of the bearings.

4. It should not have a rubbery appearance, inasmuch as this is an indication of too little water used in mixing, and such a grease will almost always separate later on.

5. It should be as free as possible from the tendency to decompose, oxidize or turn rancid on exposure to the air.

6. It should not be liable to gum or clog the oil ducts, however adverse the operating conditions.

7. It should be absolutely homogeneous and of uniform consistency throughout, and there should be no impurities or lumpy matter present to cause clogging of the lubricator, grease cup or oil ducts.

To insure the production of a grease that will conform to such of the above requirements as might apply to the lubrication job at hand, at all times the quality of the ingredients should be of the highest; the method of manufacture should be carefully studied and correctly carried out; and the manner of feeding of the grease to the parts to be lubricated should be perfectly adapted both to the grade of the lubricant and the type of machine.

Advantages of Grease as a Lubricant

The matter of comparing grease with oil for lubrication purposes involves essentially a prior consideration of machinery details and the relative adaptability of each lubricant for the service intended. The question of where and when to use grease lubrication therefore requires an intimate knowledge of machinery operation and the science of lubrication. This will be taken up later on. There are certain definite characteristics possessed by greases which tend to give them decided advantages in many cases. Theoretically grease lubrication is best suited to low speed service. By virtue of the fact that a grease film is normally thicker than an oil film (at low operating speeds) due to its generally greater body, the rate of distortion in the film will be less. It is uncertain whether this condition would hold under higher shaft speeds, since the questions of pressure, bearing area and means of applying the lubricant would, by their effects, render each case individual in its operation.

Another advantage grease lubrication presents is the usual total freedom from splashed or dripped lubricants. In certain types of machinery leakage of the lubricant to the product being handled will practically ruin the latter. This has been discussed in previous articles in LUBRICATION covering, for example, the Textile and Baking Industries. Means of lubrication on much of the equipment used therein renders cleanliness of the bearings and other wearing parts practically impossible were oil to be used. Hence, grease is resorted to, being applied by compression grease cups, gravity or pressure lubricators.

Disadvantages

It can readily be inferred from the above that inasmuch as greases are chiefly of advantage in lubricating slower speed high-pressure units wherein a relatively thick film of lubricant is desirable, they will be disadvantageous under high speed conditions. There has been exten-

sive effort in certain technical articles and advertising bulletins to promote the use of grease by decidedly ambitious statements as to its qualifications. In fact, such propaganda would very frequently lead the layman to believe that a grease is a "cure-all" wherever a lubricant is required. The use of grease, however, is clearly limited to the lubrication only of such points as are favorable to its application.

The most decided disadvantage pertinent to the use of grease is the possibility of lack of stability. Unless grease is skillfully and scientifically mixed, and the highest grade of ingredients used there will be a marked tendency towards lumpy separation of the oil and soap constituents. This occurrence will be especially likely if the grease is stored over any length of time. Separation is usually a result of using excess heat in mixing such products as cup and sponge greases. If the grease maker is not an adept at his art, frequently he will overheat the batch in an endeavor to brighten it. This is fatal and such a grease will nearly always separate sooner or later.

Another disadvantage that is frequently claimed is that greases today are relatively nonuniform in character. That is, the grades of various manufacturers will differ markedly in regard to consistency and melting point, etc. This is due to the fact that there is little or no conformity among grease makers as to specifications, especially regarding consistency, tests for which are crude and undependable. Many such products are marketed today simply under a numerical designation, and a No. 3 Cup Grease made in St. Louis may be so different from a similarly designated grease made in New York that for service adaptable to one, the other might often give rise to serious lubricating difficulties.

Where and When to Use Grease

In general engineering practice certain manufacturing and operating conditions will be frequently encountered which can not be handled effectively by lubricating oils, and it may be desirable or even necessary to resort to grease. Essentially these conditions would be:

1. When the oil can not be retained in and around the bearing, due to "squeezing out" caused by high pressure, slow rubbing speed or high operating temperature.

2. In cases where any liability of oil splash or drips would involve damage to belting or the materials being handled by the machine, as for example in the textile mill.

3. Where the bearing may be subject to repeated shocks as on the motor car chassis, which would tend to break the lubricating film.

4. Where it is desirable to insure positive lubrication using a comparatively small amount of lubricant, and yet have a sufficient reserve to enable the part to operate with relatively little attention for a considerable length of time. This particularly applies to inaccessible bearings where gravity feed grease cups are used, and where the use of oil would entail shutting down of the machinery for attention.

5. Where relatively high operating temperatures are encountered.

6. Where it is desirable that the lubricant retain its position by virtue of its physical characteristics whether the machine is idle or in motion, such as in locomotive driving journal lubrication.

In all cases of relatively high speed, or wherever the oil can be effectively applied and retained by the bearing, grease lubrication should not be used unless other exceptional conditions warrant it, inasmuch as bearing temperatures and power consumption will be increased. Nor should greases ever be used where contact with steam may be possible and the exhaust steam is returned to boiler feed.

The type of equipment available for feeding greases to the parts to be lubricated will also be a factor in determining when and where to use such lubricants.

In selecting a grease for any particular service the melting point is usually taken as the governing characteristic. For instance, cup greases are designed for compression grease cups or pin cups on bearings where little frictional heat is necessary to make the lubricant flow. Where investigation shows the operating temperature to be relatively high, the melting point of the grease used should be proportionally higher. Under extreme pressure and temperature conditions as in railroad locomotive service a harder grease which can be applied in cake form to the bearing would be necessary.

How Greases Are Made

The manufacture of lubricating greases in recent years has been developed into a science

with the chemist and grease maker as the controlling factors, and such properties as uniformity of color, texture, consistency, and gloss depend entirely upon their ability and judgment. In fact so true is this that it is possible to take two batches of exactly the same composition and make two greases of absolutely different characteristics. It is even possible to put the same compound in two different kettles and heat them to exactly the same temperature and have one product fluid and the other very hard. All of which goes to prove that grease-making is not merely a mixing and stirring of ingredients by rule of thumb. To investigate these phenomena extensive study of the action and properties of various grease-making materials has been carried out in the endeavor of the petroleum chemist to cooperate with the grease maker in improving the lubricating qualities of greases and eliminating as much as possible the drawbacks heretofore involved.

But the chemist is only a factor as far as selection and testing of grease making materials are concerned. Once they are charged in the mixing kettle the grease maker is left to his own resources and must depend upon his experience and judgment as to the condition of the batch. It is not so much a matter of telling what the grease actually is when it is drawn, but to estimate what it is going to be several days later when it has become thoroughly cooled. Of course, if the grease maker is a chemist it is only natural to expect that he can combine his dual knowledge to produce greases that will approach a correspondingly higher degree of perfection. There are even some greases which undergo a continuous change in characteristics for several days after being poured. Naturally these possibilities must be taken into account while the batches are still hot and test samples are judged. To produce these grades in uniformity day after day is conclusive evidence that the grease maker is without a doubt an artist.

The greases on the market today with the exception of certain specialties, can broadly be classified under four headings:

CUP GREASES SPONGE GREASES	Hot mixed.
ROSIN GREASES RAILROAD GREASES	Cold mixed.

Cup Greases

In general the great majority of greases on the market today may be classified as cup greases. The basic principle in the manufacture of all cup greases is relatively the same, the manner of mixing, the nature and proportion of the different ingredients and the method of working the batch making the difference in the final product. As a result, whether the product is a relatively fluid comb box lubricant or an almost solid No. 5 Cup Grease there is little difference in the method of manufacture.

All greases of this class are made by saponifying 10% to 20% of a fatty oil, with lime and incorporating mineral oil to bring the grease to the desired consistency. The fatty oil is mixed with the lime water and heated for several hours till the base of the grease is completely formed, then mineral oil is gradually added and mixed therewith. This oil should be warmed in order not to allow any extensive cooling of the batch, as this would tend to cause the formation of soap lumps. In no other grease product is there such a chance for the exhibition of the skill and knowledge of the grease maker as in the manufacture of Cup Greases. These may be mixed in one or two kettles according to the nature of the product and the facilities of the manufacturer. Usually the batch is subject to better control and more uniform consistency is possible where two kettles are used.

When it is required to meet a certain specification or match another grease, the grease maker must first determine the fat and oil to be used. Different fats will give certain definite properties. Some will give both color and odor, others will give a disagreeable odor but result in a degree of smoothness difficult to obtain with other such fats. Again certain fats will produce a soft slimy product of relatively low melting point. It is often necessary to combine more than one fat to obtain the desired results.

Before mixing is commenced the grease maker, in cooperation with the chemist must decide upon the proper proportion of lime to use and what fats or combination will result in a grease of the desired characteristics. It is a comparatively easy matter for any chemist to calculate the exact amount of lime necessary to theoretically completely saponify an oil

However, inadvertently leaving a slight amount of unsaponified fatty oil, or having an excess of lime will very decidedly change the characteristics. As either is very possible the grease maker must be fully aware of this fact and give it due consideration in handling the batch.

The kind of fat and the proportion of lime having been determined, the grease maker must then decide on the grade of mineral oil that should be used. As the latter will materially affect the characteristics of the finished grease, the purpose for which it is being produced should be taken into consideration to insure that a suitable oil will be selected to effectively lubricate the machinery upon which the grease is to be applied.

Sponge Greases

Sponge grease is a soft fibrous product having a relatively high melting point. It differs essentially from cup grease in that the base is soda soap instead of lime soap. The peculiar fibrous or spongy texture depends largely upon the amount of stirring and the way the batch is handled in the kettle. True sponge grease is a boiled product; it does not lend itself to as many variations and is not as hard to make as cup grease. Likewise its usage is limited to some extent, *i.e.*, it cannot be applied in the presence of water due to the fact that soda soap is soluble therein. On the other hand it affords an excellent film of lubricant and being neutral it does not tend to become gummy or clog up the oil ways, etc. The essential point to observe in the manufacture of sponge grease is that the water content of the final product should be as low as possible; otherwise the appearance of the latter will be mushy instead of fibrous.

Recently there have come on the market certain greases which, while they are not in reality true sponge greases, would nevertheless be included under this general classification.

As a rule they are produced with two objects in view, *i.e.*, (1) high melting points, and (2) smoothness. The base of such greases is usually a mixture of soda and lime soaps in varying proportions. In obtaining smoothness of texture the mixing temperature and the method of handling the batch in the kettle are most important. For this reason such greases are far more difficult to make and require that the grease maker be ably proficient in his art.

Cold Set Rosin Greases

These products are usually known as axle greases and constitute the cheaper grades of semi-solid lubricants that are required for rough service. They are made by mixing, while cold, the proper proportions of mineral oil, rosin oil and lime, or "set". This latter is essentially an emulsion consisting of slaked lime, a pale mineral oil, water and rosin oil. The final mixture will normally solidify in a few minutes and the resultant product will have a good body, be uniform and remain free of lumpy separation, if proper care has been observed in the mixing. It is usually drawn into the shipping containers directly from the mixing tank immediately after agitation. Such greases are comparatively easily made. The skill of the grease maker, however, is shown in a choice of stock and ability to make a smooth grease that will have the least tendency to separate.

Railroad Greases

Railroad greases in general include driving journal compound and rod cup grease. While these greases are used for different purposes their general characteristics and method of manufacture are alike. With such products it is necessary for the grease maker to know before starting a batch, exactly what will result from the proportions of the ingredients he intends to use, for there is no chance to correct a batch after starting, and a finished mixture can not be worked over. These greases are generally made by the cold saponification of hard tallow with caustic soda in the presence of a pure mineral cylinder oil. Saponification normally takes place slowly. Immediately after the batch starts to thicken it must be promptly drawn into the shipping containers where the reaction continues to completion over a period of several days.

In addition to the four general classes of greases discussed above there are many specialty products developed for particular types of service. Some of them are more or less of a freak nature. The principle of manufacture, however, would normally place them under one of the above categories.

Usual Tests for Greases

While there are a number of laboratory tests that can be made to determine the quality of any greases, essentially the melting point, or the temperature at which the grease begins to flow, will be the only one that the user can apply. The melting point will be an indication of the lubricating efficiency of the grease, knowing the operating temperatures of the parts whereupon it is to be used. While there is no doubt that other tests might interest the engineer, he normally could make but few of them with any accuracy; therefore he must rely upon it that he is purchasing from a dependable manufacturer.

The Melting Point

This is determined by coating a thermometer with the grease to be tested and then suspending it freely in an empty test tube, which is immersed in light oil. This oil bath is then gradually heated at a rate of 5° F. per minute and the temperature observed. When a drop of grease forms on the end of the thermometer and falls to the bottom of the tube, the temperature is noted as the melting point of the grease.

Conclusion

It is evident from the above that grease lubrication is governed by quite a number of factors and should be especially treated from an operating viewpoint. There is no doubt but that the lubricating value of grease, regardless of how carefully it may be manufactured, is limited to what might be called extreme conditions of operation and construction. Greases are not advisable for general all around lubrication, as certain advertising propaganda would lead us to believe, and their choice and usage should be decided upon only after consultation with lubricating engineers qualified to make recommendations by virtue of their experience in both the fields of machinery and lubrication. When greases are deemed necessary lubricants, due consideration of their properties, advantages and disadvantages will be most beneficial in deciding on the grades best adapted to the work in hand.

From the point of view of manufacture, as has been stated, the proficiency of the chemist and the skill of the grease maker are the governing factors. Once the composition has been determined it is a comparatively easy matter for anyone to make a substance that could be termed grease, though it would in all probability be dull, lumpy, and without lustre. Here is where the skill and judgment of the chemist and grease maker enter into the problem, if we are to produce uniform batches which are bright, lustrous, absolutely smooth and immune to lumpy separation, regardless of time or storage conditions.

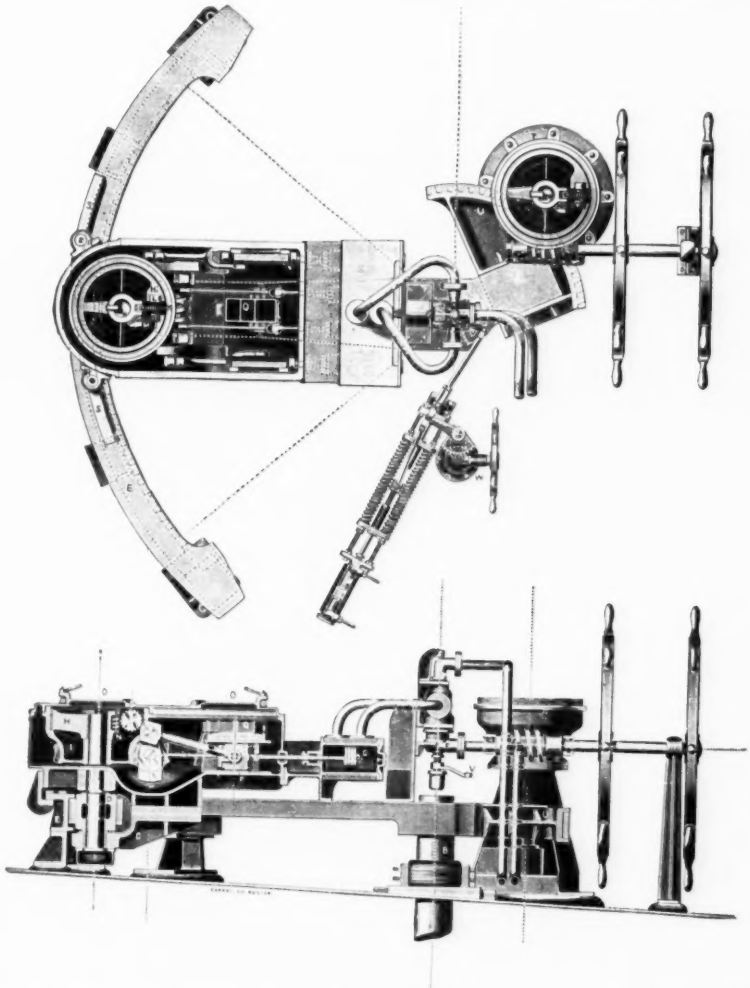
Lubrication of the Steering Engine and Deck Auxiliaries

AS A FITTING sequel to the Lubrication of Marine Reciprocating Engines and Engine Room Machinery which was discussed in LUBRICATION last month, deck auxiliaries are now taken up. Of these, the steering engine only, plays a part in the daily operation of the ship. As may be imagined it outweighs all other equipment in importance except the main engine and generator set, for upon its operation will depend the control and behavior of the ship in the hands of the helmsman. Other deck machinery is only used intermittently and is seldom subject to exacting requirements that might involve the safety of the ship.

Deck auxiliary machinery today is chiefly driven by reciprocating steam engines built as part of each unit. There is, however, a decided trend of popular opinion towards doing away with steam, and operating deck machinery such as the anchor windlass, winches, capstans and steering engine, by electric motors which receive their power from a generator set run by a Diesel or Semi-Diesel oil engine. Without a doubt this method of operation will ultimately be far more economical in fuel con-

sumption, and the usual loss of heat through lengthy steam lines and deck exhausts will be entirely eliminated.

stated above, are generally used in the merchant marine though the electro-hydraulic steering gear is coming into favor on vessels



Courtesy of Hyde Windlass Co.

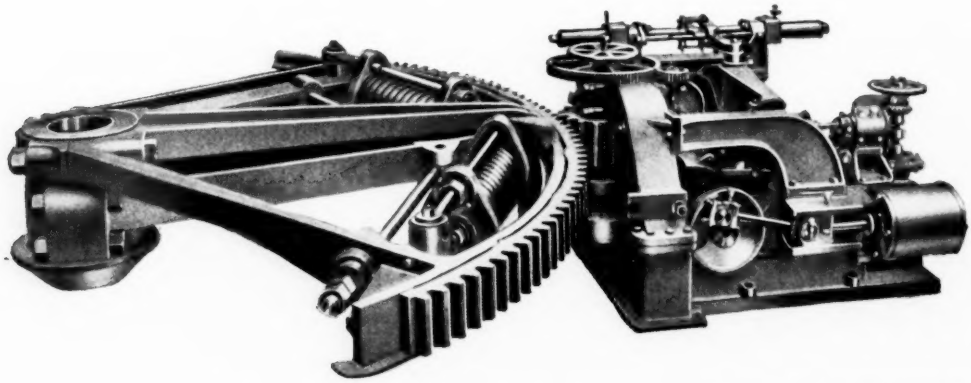
Fig. 1.—Type of Steam Tiller used extensively today, showing both plan and elevation. It is claimed for this design of steering gear that it has the fewest number of parts possible, *i.e.*, one pinion, one worm wheel and worm. Oiling is accomplished by two valveless oil pumps "pp" driven off the valve rods of the engine, the oil being thrown from a well in the bottom of the casing through a hollow piston rod into a reservoir "Q", from which a copious supply of oil is led to all working parts.

Steering Engines

The development of the modern steamship from the small crude slow speed craft of a generation ago, to the great swift cargo and passenger liners of today has made it imperative to install mechanical steering mechanisms almost universally, retaining a hand steering arrangement for emergency only, in event of damage or breakdown of the main steering engine. Steam steering engines, as has been equipped with internal combustion engines. In general there are three distinct types of steam steering engines, i.e., the steam tiller, a steam quadrant steering mechanism and a screw gear steering engine.

In the steam tiller the engine is built as an integral part of the gear and moves with it. The purpose of this mechanism is to eliminate chains and ropes, to release the rudder under abnormal strain and automatically return it to

its former position when the strain has passed, to enable an easy transition from steam to hand gear and vice versa, and to afford as simple a connection with the telemotor as possible. To attain these objectives, as has been said, the steam engine is carried on the tiller itself. Motion is transmitted from the former to the latter by an expanding friction clutch and a worm gear mechanism. This type of engine is claimed to have the simplest construction of any of the usual steam steering devices today, as well as the fewest number of parts. In this machine it is customary to mount the steam and exhaust valves just above the rudder stock, and steam admission is regulated from the pilot house via the telemotor or other suitable transmission mechanism. The motion of the tiller automatically brings about the closing of the steam and exhaust ports.



Courtesy of American Engineering Co.

Fig. 2.—Quadrant steerer fitted with a horizontal steam engine and spring quadrant. The quadrant is of the floating type secured to the tiller by heavy coil springs, the tiller being keyed to the rudder stock. The spring connections take up all stresses without danger of damage to the engine.

The steam quadrant steerer is designed to eliminate the use of chains, ropes, and sheaves, and for usage where space is limited. The quadrant is connected directly to the rudder stock, the steam engine driving it through a worm and pinion connection. In this type of steering gear the quadrant serves as a shock absorber and protects the engine and gear from rudder movements.

The third type or screw gear steering engine embodies a direct connection to the rudder stock by links which are actuated by travelling nuts carried on a screw shaft with right and left hand threads, approaching at the centre. Suitable sleeves supported by guide bars carry these traveling nuts. This type of gear is flexible in its arrangement and is an extremely compact hand and mechanical steerer combined. It is generally used where a powerful gear is essential, due to its positive action and the fact that rudder shock can ordinarily be taken up by the screw without doing any material damage.

In these two latter types of steering engines steam control is usually brought about by a device known as a follow-up mechanism in conjunction with a suitable valve gear. By this arrangement the motion created by the rotation of the steering wheel is transmitted through the telemotor, to cause admission of steam to the engine, which by its operation puts the rudder in motion. This motion continues until the rudder reaches a position corresponding to the degree the wheel has been turned. Then the steam valve on the engine automatically closes and the rudder remains in a fixed position.

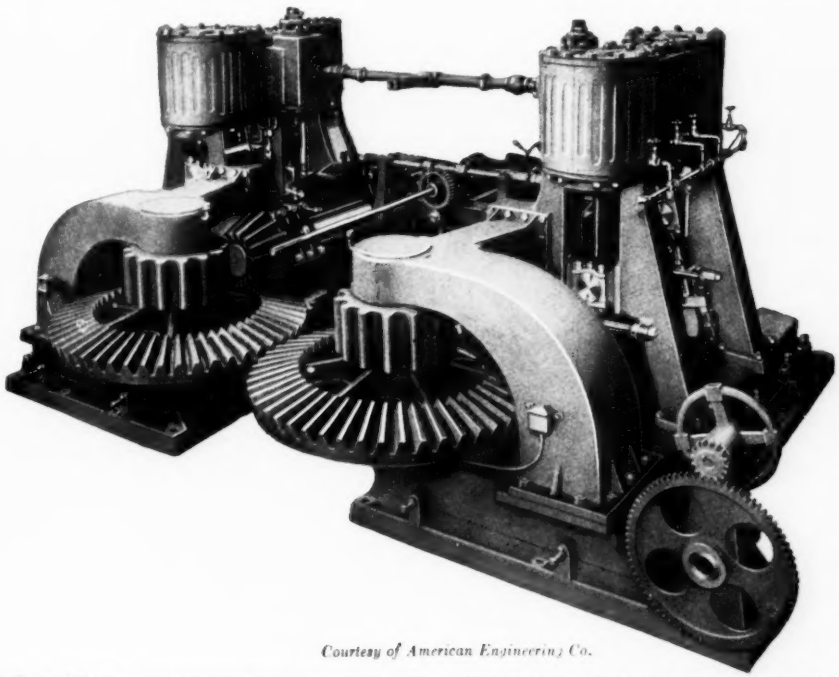
The essential details of such a mechanism are as follows: the motion of the telemotor is transmitted through a trunion and suitable leverage to actuate a fixed shaft which causes a sleeve nut to move in an endwise direction. This nut moves an attached lever to operate the steam valve, and the engine is caused to operate, turning the rudder through its connecting mechanism. On the crankshaft of the engine a rotating worm is attached which actuates a

worm gear. Through this gear and suitable lever connections the sleeve nut on the main shaft is returned to its original position and the steam valve is closed when the steering wheel becomes stationary again.

Lubrication

Steering gear lubrication normally involves no difficulties and in many cases it can be designed to be relatively automatic. Essentially three grades of lubricants are required: i. e., engine oil, cylinder oil and a gear compound. External parts such as bearings can be effectively lubricated with the same marine engine oil as is used on the main engine, or, if preferred, a pure mineral engine oil of about the same viscosity, i.e., 500″ to 750″ Saybolt at 100° F., will answer. The presence of fixed oil compound in marine engine oil will usually have no marked effect upon the efficiency of lubrication, inasmuch as the possibility of lathering will be remote. On the steam units lubrication is generally confined to swabbing of piston and valve rods, and the same grade of marine cylinder oil as used for main reciprocating engine purposes will be suitable.

Gear lubrication is essential on worm gear drives, the rudder quadrant and other gearing. The lubricant is often applied by hand on much of this equipment. Where possible, however, a very suitable means of lubricating a steering engine worm consists of a wheel which revolves in an oil reservoir in constant contact with the worm. This device is absolutely automatic and practically perfect in its operation. For all steering engine gearing a pure mineral gear compound of about 1000″ Saybolt viscosity at 210° F. will be satisfactory.



Courtesy of American Engineering Co.

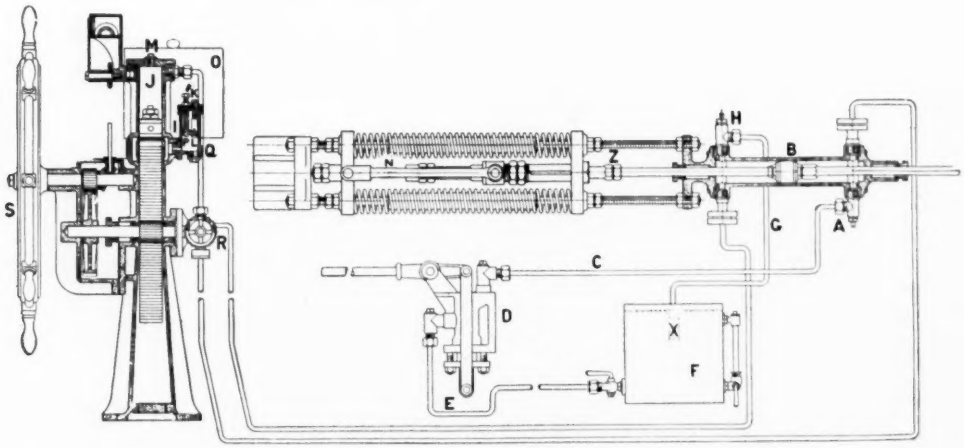
Fig. 3.—Type of Heavy Duty Quadrant Steerer equipped with vertical steam engines. This device is an extremely powerful apparatus and is applicable to the largest and swiftest vessels. The drive is a combination of spur and bevel gears. Only one engine is in gear at a time, the other being held in reserve for emergency or alternate relief. If desired an electric drive may be substituted on one side.

Lubrication of the various parts of the steam tiller is generally carried out automatically by suitable oil pumps driven from the valve rods of the engine. These throw the oil from a sump in the bottom of the casing through a hollow piston rod into an upper reservoir from which the oil flows to all working parts by gravity. For this service marine engine or turbine oil will answer admirably.

The Telemotor

To bring about control of the steam valve on the steering engine from the wheel house, a

device known as the telemotor has been developed to supplant wheel ropes and direct shafting connections. Both electric and hydraulic control systems are in use, the latter, however, predominating. Essentially this consists of two hydraulic cylinders which contain the operating and transmitting pistons. One is located adjacent to the steering engine and connected to the steam valve by suitable mechanism, the other being placed in the pilot house and con-



Courtesy of Hyde Windlass Co.

Fig. 4.—Type of Hydraulic Telemotor. This device enables a means of transmitting motion from the wheelhouse to the steering engine, as nearly frictionless as possible, however tortuous the line of connections may be. The supply tank for the liquid necessary for operation is shown at "O". Either a mixture of water and glycerine or preferably a low cold test mineral oil is used.

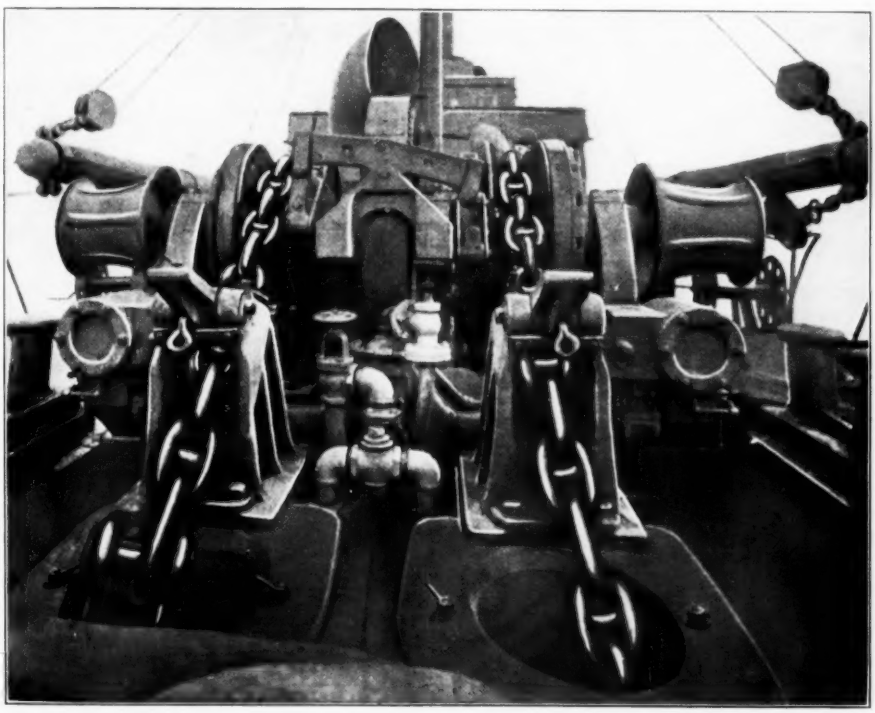
trolled by the wheel. These are connected by two parallel pipes which are filled with a mixture of water and about 30% glycerine to prevent freezing, or preferably a low cold test mineral oil of about 100″ viscosity Saybolt at 100° F. When the steering wheel is turned a rack and gear mechanism moves the transmitting piston in the wheel house cylinder, which forces the fluid through the pressure pipe to move the operating piston in the companion cylinder. This in turn controls the steam valve on the steering engine. The fluid expelled from the operating cylinder by the action of its piston returns to the transmitting cylinder through the return pipe. When the wheel is set amidships both the above pistons are brought to central position by means of springs attached to the operating mechanism, and fluid pressure is equalized in the system.

The telemotor gear requires little lubrication, except in regard to the few external wearing parts where marine engine oil and the usual gear lubricant will be satisfactory. The chief problem is to maintain the fluid in the system in a non-freezing condition. For this reason a low pour test straight mineral oil is far more dependable than a water-glycerine mixture.

The Anchor Windlass

For the handling of the heavy anchor chains the steam driven anchor engine is almost universally used on shipboard today. In general the steam engine equipment installed in an anchor engine is built with either one or two cylinders working on the same crankshaft, or two single cylinders arranged in parallel. These cylinders may be either vertical or horizontal and reversing is accomplished by a suitable valve mechanism or an eccentric capable of being changed from ahead to behind the crank at will. These steam units drive the chain drums through worm and reduction gearing the motion of the drums being relatively slow. In certain cases it may be desirable to equip the anchor engine for electric drive instead of steam, such as in ships where the engine and fireroom are located aft; thus lengthy steam lines and danger of freezing would be eliminated. In Diesel engine ships this is very general construction. In such cases the driving motors may be direct connected to the drum shaft or through a series of reduction gears.

When it is desirable to afford a means of handling mooring lines and hawsers, the windlass may be fitted with a capstan connection. Horizontal drums, known as gypsies, are usually fitted to the main shaft. The capstan is driven independently by a vertical shaft through a worm and gear arrangement actuated by the main shaft. Vice versa, the windlass can be driven by hand by rotation of the capstan when suitable locking devices are dropped into place. When it is desired to use the gypsies alone, the capstan can be disconnected from the windlass proper by use of a suitable clutch on the capstan shaft.



Courtesy of United States Chain & Forging Co.

Fig. 5.—Illustration of Anchor Engine and Chain Connections. The severity of the service that such a machine is subjected to, and the frequent exposure to the weather, afford possibility of rapid rusting or deterioration of parts, hence careful lubrication of all working mechanism is essential.

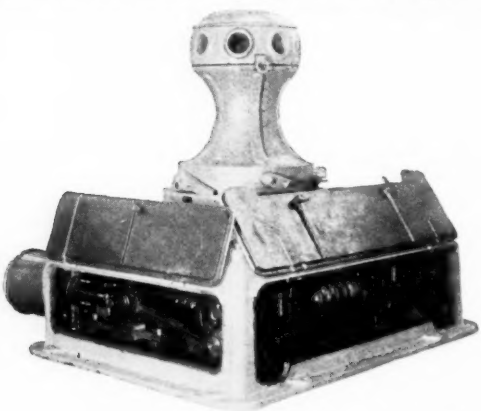
Steam Capstans

In certain cases it may be desirable to install a steam driven capstan independent of the anchor windlass, or in a special location in the ship. Such a device is usually driven by a twin-cylinder simple steam engine. The engine is carried by the same deck as the capstan but below it, and power is transmitted to the latter through a worm and reduction gear carried by the capstan shaft. Two speeds are generally provided whether the capstan is run by steam, electric or hand power, and the worm gear can be disconnected to allow the capstan to turn freely on its shaft when hand operation is desired.

Deck Winches

As part of the ship's deck equipment, winches are generally installed for the handling of heavy weights or bulky packages. There are numerous types of modern deck winches dependent upon their driving mechanism, the manner of power transmission and the number of drums. Steam engine drive is customary in the average steamship today, though electric motors may be used in special installations. As a general rule one or more single cylinder engines are used, being fitted with differential valves or Stephenson link mechanisms for reversal. Spur geared deck winches may be operated by (a)

a cone friction drum fitted loose on the main shaft; (b) by link motion; and (c) by a positive clutch device attached to the crankshaft. In the latter the drum and gear wheel are keyed to the driving shaft, the gear being driven by a pinion on the main shaft. Braking is carried out by a strap brake fitted to a suitable flange on the drum. Such a winch is often fitted with extension heads and equipped with compound



Courtesy of The Hadfield-Penfield Steel Co.

Fig. 6.—Type of steam driven capstan frequently installed for warping purposes. This machine can be also operated by hand if desired by disconnecting the worm gear to allow the capstan to turn freely.

gearing for extra heavy duty such as in large naval and passenger ships. Frequently worm gearing is used instead of spur gears for operating the main driving shaft. This arrangement is capable of great power.

Friction gearing, wherein the engine drives a friction spur gear or pinion which engages with a friction wheel on the drum shaft, is also commonly used. Such winches permit of fast hoisting and rapid operation without undue danger or strain on the machine. They are frequently built with double drums capable of independent operation, each being driven by its individual operating mechanism.

Lubrication of Anchor Windlasses, Capstans and Deck Winches

In view of the fact that the above machinery is almost always exposed to the weather and to the deleterious action of salt spray and sea water, careful attention should be given to its lubrication and the protection of the working parts. Essentially the problem involves the lubrication of gearing and bearings. Steam cylinders, even though they are usually horizontal, seldom receive lubrication except by the little engine oil that may be carried inside when piston and valve rods are swabbed. Usually waste pad lubrication is customary on all shaft bearings, due to the intermittent service that such machines are given. For this purpose the same grade of marine engine oil that is used on the main engine is suitable, or often reclaimed oil from the engine room can be used. Other moving parts such as crossheads, guides and pins are usually hand lubricated, using the same oil as above. In the case of electrically driven machinery the electric motor bearings are usually built for ring or chain oiling, and a straight mineral oil of from 180″ to 200″ Saybolt viscosity at 100° F. should be used for lubrication. It is essential that the oil should have as low a pour test as possible if it is to be used under low temperature conditions, and the engineer should ascertain as nearly as possible what latitudes the ship has to enter in order that he may select his oil accordingly. Gearing should be periodically treated with the best possible gear lubricant obtainable to protect the teeth while idle and not entail too great a consumption of power when in operation. A straight mineral lubricant of about 1000″ viscosity Saybolt at 210° F. is best suited for this purpose.

Conclusion

Due to the magnitude of the subject and space limitations it has been only possible to discuss the features of the marine reciprocating steam engine, and the appertaining engine room and deck auxiliaries in a cursory manner. Sufficient description has been given, however, to emphasize the importance of correct lubrication, and the part that it plays in the efficient operation of the ship. In marine practice lubrication is a far more vital factor than in the stationary plant. Failure of a bearing, etc., in the latter would normally only mean a certain amount of inconvenience. On shipboard, however, the entire safety of the vessel and its passengers might be put at stake were a failure in the lubricating system of the main engine, generator set or steering engine to occur. Therefore the utmost care must be exercised at all times, not only in the application of the lubricants, but in their selection, care and handling

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